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The impact of technological innovation and governance institution quality on Malaysia's sustainable growth: Evidence from a dynamic relationship

Hussain Ali Bekhet*, Nurul Wahilah Abdul Latif

Graduate Business School, College of Graduate Studies, Universiti Tenaga Nasional (UNITEN), Kajang, 43000 Selangor, Malaysia

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A B S T R A C T

Technological innovation integrated with strategic policies is vital for sustainable growth. This study aims to highlight the importance of technological innovation and governance institution quality on Malaysia's sustainable growth from 1985 through 2015. The dynamic relationships among gross domestic product, capital, employment, electricity consumption, technological innovation, governance institution quality, and the interaction of technological innovation and governance institution quality are examined. The augmented production function, F-bound, dynamic ordinary least squares, and Granger causality tests are utilized. The results confirm the dynamic relationship among the above variables. In the long run, unidirectional causality runs from governance institution quality and technological innovation-governance institution quality toward Malaysia's financial development. However, in the short run, there is bidirectional causality between financial development and economic growth. The interaction between technological innovation and governance institution quality has a significant positive impact on Malaysia's economy in the long run. Also, capital, employment, and electricity consumption have a positive significant impact on economic growth in the long run. These three variables are vital growth inputs and should be accompanied by technological innovation and governance institution quality. Well-planned and relevant policies can boost technological progress in Malaysia, slowly yet surely.

1. Introduction

Sustainable growth and development remains a major challenge for all countries. Indeed, it has become a main agenda for all countries, both developed and developing. Stagnant growth, global economic volatility, and macroeconomic shocks have recently raised concerns in countries across the globe. Sustainability issues have been discussed since the Brundtland Report [1], with the aim to attempt sustainable long-term growth and development (social, economic, and environmental) while safeguarding future generations. In general, increases in the factors of production, improvements in efficiency in allocating the factors of production, and the rate of innovation are the major forces of growth [2,3]. Heavily depending on traditional production functions such as capital and labor to sustain economic growth and continued dependence on it in the long term is not an option. Developed countries have long ago switched from using traditional sources of growth like capital and labor to technological innovation. For example, South Korea, Taiwan, and Singapore are progressively moving to technological innovation methods of production [4]. Endogenous growth theories point out that technological change has a significant impact on global growth patterns [5,6].

To date, the general consensus has been that new technology adoption is important to facilitate technology catch-up [7,8] and foster innovation in the 21st century [9–11]. New technology adoption may even resolve the uncertainty about the economic growth rate, environmental issues, and the depletion of energy resources. Studies have shown that technological innovation is the main driver of long-run growth [12,13]. This is because as producers add an additional input (i.e., capital or labor), the additional output obtained will eventually decline over time, according to the law of diminishing returns. Also, such innovation supports productivity through new or enhanced processes, technologies, and business models that create differentiated products and services. At the same time, it creates additional sources of revenue. However, a

* Corresponding author.
E-mail addresses: Profhussain@uniten.edu.my (H.A. Bekhet), nurulwahilah@uniten.edu.my (N.W.A. Latif).

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country cannot maintain long-run growth simply by adding more capital and labor. Thus, technological innovation is the alternative solution to achieve a continuously ascending growth rate for a country [14]. The growing concern about sustainable development, diminishing energy resources, and environmental issues drives policy makers to find solutions domestically and globally [15]. However, innovation is seen as a "double-edged sword" for achieving sustainable development in terms of both attempting long-term economic growth and resolving environmental issues.

The increasing number of scientific, technological, and innovation achievements, together with well-organized intellectual property laws, demonstrates how important technological innovation is to achieve a better economic outcome and sustain a country's growth rate [16]. Technological innovation can become reality with the help of quality governance institutions. The relationship between quality of governance and economic growth is rather complex [17]. Governance is actually a form of the "social technological" that facilitates economic activities, shapes the behavior of economic agents [18], and optimizes economic decisions, collectively and individually [17].

Over the last five decades, Malaysia has experienced rapid economic growth, as well as social and environmental transformation [19]. As a developing country, Malaysia is in the midst of a transition to attain sustainable growth and development to become a high-income nation and fulfil Vision 2020. A 6% annual gross domestic product (GDP) growth is targeted over the 11th Malaysia Plan [20]. However, achieving the targeted annual growth rate will involve input factors beyond capital and labor. Technological innovation offers by far the best solution; this has been recognized by many researchers, practitioners, and governments. Indeed, technological innovation is a main driver for a country to attain sustainable economic growth and competitive advantage [21]. The idea is that such innovation leads to new ideas and new methods, new production practices, and new management skills which become breakthroughs, so-called novelties. Schumpeter [22] highlights the term constructive disruption, which suggests that any obsolete technology will be put away and replaced with a new one. This is a continuous process and no country that avoids this process will flourish. Any governmental delay in decisions, commitment, progress, and efforts in the technological innovation process will affect the country as a whole, socially, economically, and environmentally. Moreover, catching up in terms of technological progress takes many years for countries that have been left behind. Indeed, innovation can allow countries to grow consistently at a sustained rate. Nevertheless, motivating and fostering the innovation process requires sustained, gradual, and continuous effort [23].

According to Fagerberg et al. [24], the 1990s onward show a twisted shift in development of research in technological innovation. Recent studies have focused on the role of innovation in the entire economy and how the quality of governance institutions and policies play a vital role which in turn benefits the country [25,26]. Thus, a society can enjoy the full benefits of innovation and its diffusion. Chang and Fang [27] infer that institutional, technological, and market-based approaches should be implemented to increase energy efficiency, improve energy equity, and secure sustainability. In pursuit of sustained growth and economic development, Malaysia has committed to provide institutional changes and a better regulatory environment to promote innovation [28].

Technological innovation is a catalyst for developing countries like Malaysia. It is a key influencer to drive long-term economic growth and sustainable development. The current 11th MP [20] highlights technological innovation as an important agenda for the Malaysian government [20]. Bekhet and Latif [2] point out that the Malaysian economy still relies on capital and labor instead of multifactor productivity (MFP), which is contributing about 70% of GDP growth. Furthermore, MFP has been stagnant in terms of real growth; while, the share of MFP in growth decelerated in the 9th MP [29] and 10th MP [28]. This stagnation period for two MPs has indeed caused concern among policy makers. So, the government has made a rigorous effort to strengthen the MFP input factor during the 11th MP. The goal is for the ratio of MFP to GDP growth to increases to 40% (Fig. 1). The Malaysian government has targeted an emphasis on multifactor productivity input of up to 2.3% (real growth) with clear outcomes at all levels (national, industry, and enterprise) [20].

Therefore, it is a great challenge for Malaysia to formulate suitable strategies to increase the innovation rate and ensure that innovation implementation is a continuous effort. Fig. 2 shows that the economy maintained an average growth rate of approximately 5.72% from 1985 to 2015. The growth rate trend and performance change throughout the period depending on global and domestic factor variations. Economic growth averaged over 1970–1980 and 1980–1990 is 8% and 5.4%, respectively [30]. Furthermore, for 1999–2000 and 2000–2015, economic growth averaged 6.8% and 4.8%, respectively [31]. The growth rate steadily trends upward for 1985–2015, with two drops during the Asian financial crisis (AFC) (1997–1998) and global financial crisis (GFC) (2008–2009) [32]. Based on this changing performance – Malaysia's growth rate dropped from 8% (1970–1980) to 4.8% (2000–2015) – policy makers seek to increase the country's current growth rate, with a target of annual growth of 5%–6% during the 11th MP [20]. Meanwhile, technological innovation in Malaysia has displayed an upward trend throughout the years (1985–2015), with a growth rate of 5.68%. Growth in the number of patent applications fluctuates throughout the 1985–2015 period, with a low of 232 in 1987 and a high of 2372 in 2007 during the AFC and GFC, respectively. The trends have shared the same direction since 2008.

This study seeks to better understand the factors that determine sustainable growth, particularly in Malaysia, by integrating theoretical developments in the technological innovation (financial development) and governance institution quality literature. Technological innovation has received considerable attention from researchers and policy makers. Innovation is everywhere, but existing materialized and testable research that provides accurate measurements is a bit scarce, especially in developing countries like Malaysia. Thus, this paper makes a courageous effort to provide and materialize research regarding technological innovation and the importance of governance institutions in igniting technological innovation in Malaysia.

Therefore, this study aims to examine the long-run relationships among the variables of real gross domestic product (GDP), capital, employment, electricity consumption, financial development, governance institution quality, and interaction of finance-institutions in Malaysia. Furthermore, the intent is to investigate the elasticities of real GDP and its determinants and to confirm the direction of causality among the above variables. The contributions of this study are as follows: (1) This study contributes to both knowledge and the literature by focusing on technological innovation and the significance of governance institution quality in promoting innovation, (2) it attempts to capture the interaction of technological innovation and governance institution quality on economic growth in the case of Malaysia, and (3) it enhances past research [34] by investigating the interaction impact of finance-institutions on sustainable growth.

The rest of the paper is organized as follows: Section 2 reviews Malaysia's economy and technological innovation. Section 3 discusses the literature on technological innovation, governance institutions, and economic growth. Section 4 explains the data

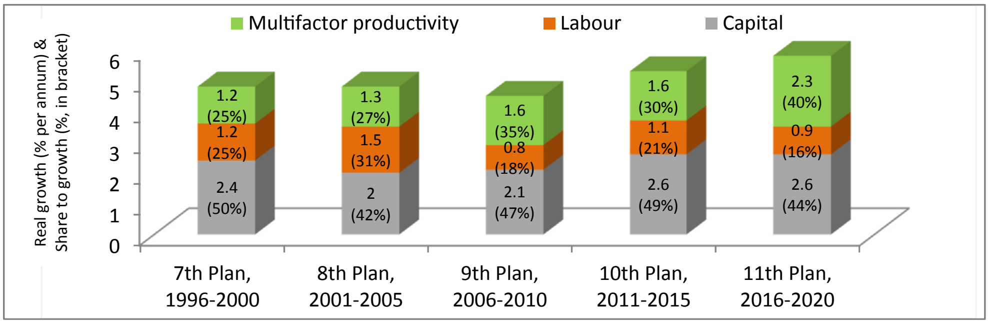


Fig. 1. Malaysia's sources of growth, (2010 = 100).
Source: [20].

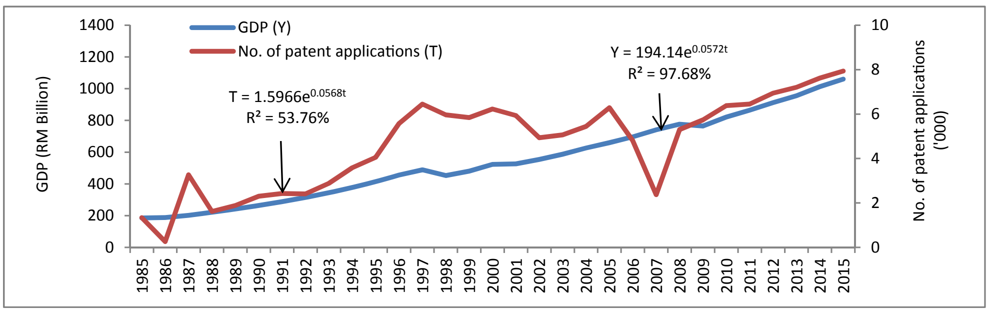


Fig. 2. Time trend of real GDP (2010 = 100) and no. of patent applications for the (1985–2015) period.
Source: [33].

sources, model construction, and methodologies. Section 5 provides the empirical results and, finally, conclusions and policy implication are presented in Section 6.

2. Malaysia's economic development and technological innovation progress

In the 1950s, Malaysia began its planning development program to formulate progressive and consistent growth. The country has a three-tiered program covering the long, medium, and short term and consisting of various policies, plans, and annual budgets to set directions, targets, and estimated costs. Based on the planned program, Malaysia's economy can be divided into three important phases, which are an agriculture-based economy, a resource-led economy, and an innovation-led economy. The Malaysian government aims to make the nation a high-income nation that is sustainable and inclusive by 2020 [20]. Malaysia's development plans and policies are summarized in Table 1.

Well-structured and efficient infrastructure drives economic performance [2] because of its large multiplier effect, particularly in developing countries [36,37]. According to the Global Infrastructure Investment Index (GIII), Malaysia ranks fifth in terms of its attractiveness for infrastructure investment in Asia [38]. In the 11th MP, the government aims to strengthen Malaysia's infrastructure to boost productivity and propel economic expansion. Continued long-term investment in infrastructure has made Malaysia's markets attractive. Thus, it has brought in private/inward investment. Also, Fig. 3 shows that capital steadily increases at an average annual growth rate of 8.8% per year for the 1985–2015 period. The focus has been on transport, digital, and energy infrastructure due to rising demand from the public and various economic sectors [20]. Necessary infrastructures, like roads, rails, water, and electricity, have been enlarged to accommodate communities' need. The government is now in the midst of planning a strategic development framework (SDF) for the high-speed rail (HSR) project linking Kuala Lumpur and Singapore [2,39], which will shape the direction of socio-economic development. Recently, mass rapid transit (MRT) was launched to the public phase by phase with the aim of having fully integrated public transportation for the nation by 2020 [40].

Meanwhile, employment (human capital) is a vital factor for the sustainability of the nation. It plays a significant role in terms of absorption capacities and technology know-how to boost economic growth [41,42]. Malaysia's employment has progressively increased from 6 million in 1985 to approximately 14 million in 2015 [31] with an average annual growth rate of 3% (Fig. 3). According to Teles and Joiozo [5], level of education is important when it comes to technological innovation. Vandenbussche et al. [43] argued that only the tertiary educational level boosts innovation; the secondary educational level promotes only the imitation of new technologies. This scenario exists in countries far from the technological frontier, resembling developing countries. In Malaysia [20], has recognized that skilled workers (managers, professionals, technicians, and associate professionals) account for 28% of total employment in Malaysia and set a target of up to 35% over the next five years in high-value-added industries toward Vision 2020.

Furthermore, financial development is a crucial factor in stimulating economic growth, especially in a developing country like Malaysia. It is notable that a country's success is partly attributed to its financial sector liberalization and innovation. In developing countries, such as Malaysia, a strong and deepening financial sector is needed to increase productivity and sustain economic growth. Thus, analysis of the financial development contribution over the long run is crucial to sustain long-run economic growth [2]. Efficiency in the financial sector is essential to facilitate capital accumulation, provide saving and investment mobility [44,45], and

Table 1
Summary of Malaysia development plans and policies.

LONG TERM PLAN	MEDIUM TERM PLAN		SHORT TERM PLAN	AIM
Economic, Social and Development Plan Policy [1966–1970]	1st MP	1966–1970	ANNUAL BUDGETS	-It focused on social and economic development.
New Economic Policy (NEP) [1971–1990]	2 nd MP	1971–1975		-It aimed to eradicate poverty and restructure society.
	3rd MP	1976–1980		-It aimed to attempt national unity and to achieve socio-economic development
	4th MP	1981–1985		
	5th MP	1986–1990		
National Development Policy (NDP) [1991–2000]	6th MP	1991–1995		-It targeted to achieve balance development of the major sectors of the economy and to lessen socio-economic inequalities
	7th MP	1996–2000		-It targeted to enhance growth, structural transformation and attain balance development.
National Vision Policy (NVP) [2001–2010]	8th MP	2001–2005		-It targeted to sustain growth and competitiveness.
	9th MP	2006–2010		-It aimed to attempt sustainable development and to be high income country
National Transformation Policy (NTP) [2011–2020]	10th MP	2011–2015		-It targeted to create environment for unleashing economic growth and moving towards inclusive socio-economic development.
	11th MP	2016–2020		-It aimed to anchoring growth on people. -It aimed to become a high-income country which is inclusive and sustainable.

Note: MP refers to Malaysian Plan.
Source: [35].

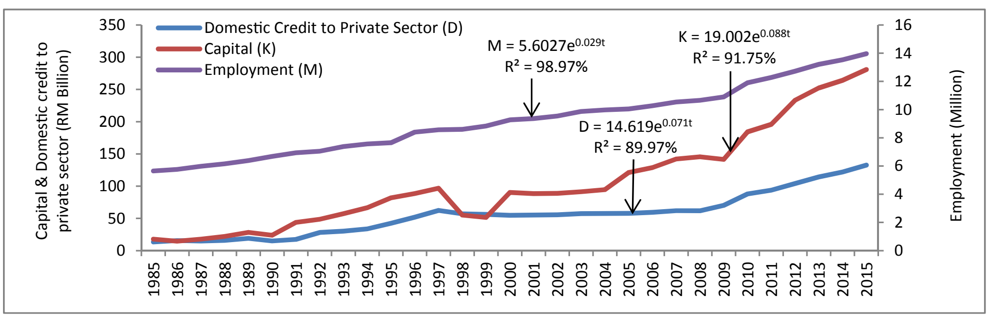


Fig. 3. Capital, domestic credit to private sector (2005 = 100) and employment for the (1985–2015) period.
Source: [33].

finance tangible and intangible investments, thus enabling innovation [46]. Past studies have demonstrated that financial development is positively related to growth because it eases access to credit, which enables the initiation of capital-intensive projects and, most importantly, provides funding for research and development (R&D) [47–49]. Lack of credit availability can affect the resource allocation and further reduce investment [50,51]. As innovation needs significant amounts of investment, financial innovation is indeed important to make the fast transactions needed. The private sector has an opportunity to develop and grow by using facilities provided by financial institutions, which indeed affects the economy of the country as a whole. In Malaysia, domestic credit to the private sector (D) has grown steadily at 7.1% per year (Fig. 3).

In addition, electricity is considered a catalyst for economic and social development, especially in developing countries like Malaysia [52]. Electricity is necessary for any economic activities like production, industrialization, and modernization and for societal well-being, including basic needs, life style, and urbanization. Fig. 4 shows that population and electricity consumption share an upward trend and grew steadily at 2.3% and 8.4%, respectively. Also, industry value added and services value added grew gradually at 5.8% and 6.7%, respectively, for the 1980–2015 period. Modernization involves an evolution process, in which the country transitions from an agricultural economy to an industrial economy to a predominantly service-oriented economy. Also, Fig. 4 shows that services value added accelerates faster (6.7%), while accompanied by industry value added (5.8%), where both share the same upward trend with electricity consumption. In this case, industrialization, modernization, the new life style, and post-materialism demand huge amounts of electricity needed. However, many researchers have discussed the importance of electricity as compared to other forms of energy, as electricity is a clean and safe energy source [53–56]. In Malaysia, to date, 97.6% of all sectors and communities have access to electricity [20]. Electricity consumption (EC) and electricity generation (EG) follow the same direction in path movement and this is expected to continue in the future. EC has grown steadily at 8.4%, while EG has grown gradually at 8.1% [53]. Then, the growth rate of electricity demand and supply must be manageable in terms of sustainability, affordability, and alternative electricity resources like renewable energy (RE) technologies to ensure the competitiveness of the Malaysian economy in the future [53,57,58].

3. Literature review

Past researchers and policy makers have widely discussed economic growth determinants like capital, labor, trade openness, foreign direct investment, and electricity consumption. Recently, the importance of the technological innovation factor to achieve economic sustainability in the long run has raised debate [13]. Moreover, achievement of any technological process must be supported by governance institution quality to shift the country's paradigm to sustainability growth [17,59]. Some researchers have used patent and R&D as proxies to represent technological innovation [52,60,61]. Meanwhile, other authors have used financial

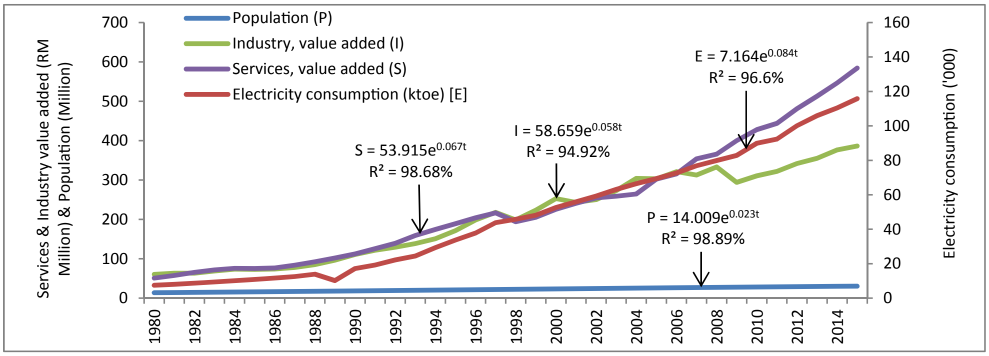


Fig. 4. Time trend of services value added, industry value added, electricity consumption and population for the (1980–2015) period. Source: [33].

development and foreign direct investment as proxies to represent technology [53,62–65]. Table 2 presents related material regarding the relationships among technological innovation, governance institutions, and economic growth.

Technological innovation has garnered interest among academicians, researchers, policy makers, and practitioner as the most prominent determinant of growth to sustain long-run growth. Despite a number of studies investigating technological innovation, little research has examined the interaction impact of technological innovation and governance institutions. In other words, the innovation impact is at the beginning stages of economic growth and it can be slow and difficult to visualize by the economies. The ultimate effect of innovation is ambiguous [84,85] without contributions from governance institutions, especially in developing countries. A high-quality governance institution makes possible the achievement of upgraded technological innovation in the country. According to Tang and Tan [61], technological innovation is the most crucial factor contributing to long-term economic growth based on the neoclassical and endogenous growth theory. In general, we can conclude that the empirical results of these studies are scant, especially for developing country like Malaysia. The main constraint is available data, especially for developing countries. Therefore, this study seeks to highlight the importance of technological innovation and the interaction impact of finance-institution in production function theory as a new determinant of growth in Malaysia. Based on the above discussion, the hypotheses are formulated as below:

H1: Significant dynamic relationship exists between economic growth and its determinants (K, M, E, F, I, and N) in Malaysia.
H2: Significant long-run causality runs between economic growth and its determinants (K, M, E, F, I, and N) in Malaysia.
H3: Significant short-run causality exists between economic growth and its determinants (K, M, E, F, I, and N) in Malaysia.
H4: Technological innovation and governance institution quality interaction has a significant positive impact on economic growth.

4. Data sources and methodology

4.1. Data sources and model construction

The annual data of real GDP, capital, total employment, electricity consumption, financial development, governance institutions, and finance-institution interaction for 1985–2015 are utilized [Table 3]. The data are collected mainly from World Development Indicators (WDI), except for governance institution where the data are collected from the International Country Risk Guide (ICRG) at a constant price (2005 = 100). The analysis work is performed using Eviews version 9.0 and Microfit 5.0.

The main objective of this study is to examine the impact of technological innovation, which is proxied by financial development, governance institution quality, and interaction of finance-institution, on economic growth by incorporating capital, employment, and electricity consumption. In past decades, numerous studies have discussed the relationship between economic growth and its determinants. Recently, many studies have pointed out the importance of the technological innovation-growth nexus. Thus, the importance of governance institution quality has been highlighted as a mechanism to increase technological innovation progress. Past research contributions include Law et al. [59], Al Mamun et al. [17], and Jores and Law [68]. In this regard, many researchers have used production theory to find the relationship among the economic factors of production [52,53,62,63,86]. Therefore, to investigate the long-run and short-run relationships among these factors, the augmented Cobb-Douglas production function (AC-D) is employed, as in Equation (1) [60,91].

$$Y_t = A_t K_t^{\alpha 1} M_t^{\alpha 2} E_t^{\alpha 3} e^{\nu} \tag{1}$$

where Y_t, K_t, M_t, and E_t are defined as in Table 3. Meanwhile, e is error term which is assumed to be homoscedastic and normally distributed and α_1, α_2, and α_3 represent the return to scale. A_t is the technological parameter generated by additional variables (other than traditional production factors like capital and labor). Therefore, A_t can be represented by technological progress (e.g., foreign direct investment, financial development, trade openness, energy or electricity consumption) [30,63–65,92]. Thus, the A_t term in Equation (1) can be rewritten as in Equation (2).

$$A_t = \theta . F_t^{\alpha 4} I_t^{\alpha 5} N_t^{\alpha 6} \tag{2}$$

where θ is a time-invariant constant, F denotes technological innovation proxied by financial development [53,62–65]. Meanwhile, I_t indicates governance institution quality and N_t represents interaction of financial development and governance institution quality. Furthermore, α_4 measures the elasticity of output with respect to technological innovation (financial development) and α_5 is the elasticity of output with respect to governance institution quality. Meanwhile, α_6 indicates the elasticity of output with respect to the interaction of finance-institution. The governance institution quality index consists of three indicators: control of corruption, law and order, and bureaucracy quality [17,93]. It takes a value from 0 to 1, where 1 indicates a perfect institution and 0 indicates the worst institution. Past studies have pointed out that

Table 2
Past studies on relationship between electricity consumption and economic growth-technological.

Authors	Countries	Methodology	Variables used	Results			
				Impact/ Relationship	SRC	LRC	Co-integration
Technological innovation							
[62]	Malaysia 1971–2015	ARDL, VECM causality	C, Y, U, U^2, K, E, F	–	–	–	✓
[53]	Malaysia 1982–2015	ARDL, VDC, IRF	Re, K, L, Y, F	F→Re[+]	–	–	✓
[66]	OECD 1970–2016	Panel cointegration GC	I, Y, ICT, Gce,K, Fd, O	–	–	I↔Y	✓
[67]	Spain 1980–2007	Panel cointegration	RD, Sc, H, Tf	P [+,ns]	–	–	–
[68]	Malaysia 1970–2010	ARDL, VECM	-I, Fd, H, O, F, RD -I, Fd, H, O, F, RD, Fd*H	RD→I[+] RD→I[+]	–	–	✓ ✓
[69]	Malaysia 1985–2012	ARDL, VECM, DOLS	C, E, Y, Y^2, Fd, Ti	[-,ns]	Y→Fd P→Yc	–	✓
[70]	China 1999–2013	Panel unit root, Panel cointegration, Panel ECM, FMOLS	P_e, Y, RD, Ep	RD→P_e[+] Y→P_e[+]	–	–	√p
[71]	6 major developed countries 1980–2010	Panel unit root, Panel cointegration, Panel ECM	Re, Yc, Op, Ret	Re↔Ti, Yc→Re, Ti	–	–	✓
[60]	Malaysia 1985–2012	ARDL, DOLS	Ec, Yc, P, O	P→Y[-,ns]	–	–	✓
[72]	61 countries 2003–2008	TC indicators	PCA, TCi	TCi→I→Y	–	–	–
[73]	Norway (N) New Zealand (NZ) 1971–2010	ARDL, VECM GC	Ce, C, P, Y	–	P→Y [N & NZ]	–	✓
[63]	Bahrain 1980Q1-2010Q4	ARDL, VECM GC	Y, E, Fd, K	Fd→Y	–	–	✓
[23]	32 countries (1976–2006)	Panel	P, Ci, Or, Ge, RD, De, Ht, Cr, Eq, V, X	F, Ht, Eq→I[+]	n/a	n/a	n/a
[61]	Malaysia 1970–2009.	ARDL GC	El, Y, Ep, P	–	P→Y P→El	–	✓
[65]	Malaysia 1971–2009	ARDL, VECM GC	E, Y, Po, F	–	F↔E	–	✓
[74]	Barbados 1960–2004	VECM, GC, IRF, VDC	Y, K, L, El, P Y, K, L, T, R, NR	[+]	P→Y	–	✓
[75]	73 countries 1980–2005	Panel FE	Yc, P, IP, K, S, O, Fr, Le, Mr, Up, Pd, Po, Fd	P→Yc[+] IP→Yc[+]	n/a	n/a	n/a
[16]	China 2004 Manufacturing sectors (128)	Regression	RD, Fd, X, M, Ip, Tp, Lq, Ki, Fs, Soe	[+]	n/a	n/a	n/a
[76]	China 1995–2006	Regression	Y, K, L, E, Tp	Tp→Ei[-]	n/a	n/a	n/a
[77]	Japan, South Korea 1963–2005	VECM	P, Y	–	P↔Y(J) Y→P	–	√(J)
Governance institution							
[17]	50 OECD 1980–2012	CD, CCEP	Yp, Or, F, Ic, Gi, Sc, K, Gs, O, L, Eg	Gi→$Y_{SR/LR}$ Ic, Sc, Gi, F [+]	n/a	n/a	n/a
[34]	75 DDC 1996–2010	GMM	P, F (Psc, Dc), F^2, Gi, O, Fd, Yc	∩	n/a	n/a	n/a
[59]	87 countries 1984–2014	GMM	Yc, F, Gi, P, Iv, H, O, fd, Gs	F*Gi→Y	n/a	n/a	n/a
[9]	45 SSA countries 1960–2010	DEA, Panel	H, O, Po, Gs, I, Gi	Gi≠Ti H→T[+] H→I[ns]	n/a	n/a	n/a
[78]	23 OECD countries 1990–2010	PRM, NBRM Panel	Ir, Dp, Dpm, Pf, Sp, Ni	Pm→I[+]	n/a	n/a	n/a
[79]	47 countries 1990–2009	Panel	Tf, RD, O, Fd, Gi	Gi→Pr Gi→Ti	n/a	n/a	n/a
[80]	85 countries 1980–2008	Hansen Threshold effect	Y, F, Gi	F→Y (Gi)	n/a	n/a	n/a
[81]	129 countries 1965–2008	Panel	Y, F, IVip, D	–	F↔IVip	–	–
[82]	63 countries 1996–2004	GMM	F, Gi, Yc, O, Fo	Gi→Bs, U_{Sm}	n/a	n/a	n/a

Table 2 (*continued*)

Authors	Countries	Methodology	Variables used	Results			
				Impact/ Relationship	SRC	LRC	Co-integration
[83]	14 EU 1990–2002	3SLS	Yc, Gi, Sc, IVs	Gi→Yc	n/a	n/a	n/a
[18]	72 countries 1978–2000	PMG	Yc, K, F, Gi	F*Gi→Y	n/a	n/a	n/a

Note: →,↔,≠, denote, unidirectional causality, bidirectional causality, and neutral, respectively. SRC: short run causality, LRC: long run causality, C: carbon emissions, U: urbanization, F: financial development, E: energy consumption, El: electricity consumption, Ec: energy consumption per capita, Elc: electricity consumption per capita, Y: real or nominal GDP or GNP, Yc: real GDP per capita, K: capital, L: labour, T: Technology, I: innovation, Gi: governance institution, P: patent, Tp: technological progress, RD: research and development, Po: population, In: inflation, Ep: energy price, P_e: energy patent, Re: renewable energy, Ret: renewable energy technological, Op: oil price, PCA: principal component analysis, TCi: total capacity indicator, Ce: clean energy consumption, Ci: citation, Or: originality, Ge: generality, De: dependency, Ht: high-tech, Eq: equity, Cr: credit, V: value-added, R: residential, NR: non-residential, Sc: social capital, H: human capital, IP: intellectual property rights index, S: schooling, Fr: fertility rate, Le: life expectancy, Mr: mortality rate, Up: urban population, Pd: population density, Tp: technological purchase, Ip: innovation performance, Lq: labour quality, Ki: capital intensity, Fs: firm size, Soe: state owned enterprise, Tf: total factor productivity, Ti: technological innovation, IVip: independent variables for intellectual property rights, D: dummy, Bs: banking sector; Sm: stock market, X: export, M: import, O: trade openness, Fd: foreign direct investment, Ic: information communication technology, Gs: government spending, Eg: economic globalization, Psc: private sector credit, Dc: domestic credit, Iv: investment, Ir: innovation in EE residential, Dp: EE domestic policy, Dpm: EE domestic policy mix, ns: not significant, Pf: EE policies adopted by foreign countries, Sp: similarity degree of between domestic and foreign policy mix, Ni: national innovation system, Pm: policy mix, Pr: productivity, Fo: financial openness, IVs: independent variables, ICT: information and communication technology, Gce: government consumption expenditure, SSA: sub-Saharan African, DDC: developed and developing countries, VAR: vector autoregressive, VECM: vector error correction model, ECM: error-correction model, EG: eagle granger, EI: energy intensity, GC: granger causality, ARDL: Autoregressive distributed lag, TY: Toda-Yamamoto, IRF: impulse response function, VDC: variance decomposition, DOLS: dynamic ordinary least square, FMOLS: fully modified ordinary least square, FE: fixed effect, OECD: organisation for economic co-operation and development, CD: cross-sectional dependence, CCEP: common correlation effect pooled mean group, PRM: poisson regression model, NBRM: negative binomial regression model, GMM: generalized method of moments, DEA: data envelopment analysis.

governance institution quality matters to enhance technological innovation, which in turn can support sustainable growth [17,59,94]. Then, substitute Equation (2) into Equation (1) to provide Equation (3).

$$Y_t = \theta . K_t^{\alpha 1} M_t^{\alpha 2} E_t^{\alpha 3} F_t^{\alpha 4} I_t^{\alpha 5} N_t^{\alpha 6} e^{\nu} \tag{3}$$

However, to achieve the objectives of the current paper, Equation (3) can be rearranged to a linear form by transforming all the variables into natural logarithms. This procedure provides consistent results, an elasticity measurement which can be used for policy-making purposes [91,95–99]. Then, Equation (4) is used.

$$LY_t = \delta + \alpha_1 LK_t + \alpha_2 LM_t + \alpha_3 LE_t + \alpha_4 LF_t + \alpha_5 LI_t + \alpha_6 LN_t + \nu_t \tag{4}$$

where $\delta = L\theta$. The relationship coefficients α_i [$i = 1, \ldots, 6$] are interpreted as elasticities.

stationarity of a series can strongly influence its behavior and properties for further model regression (e.g., the existence of economic shocks). The augmented Dickey-Fuller (ADF) [100], Phillips-Perron (P-P) [101], Kwiatkowski-Phillips-Schmidt-Shin (KPSS) [102], and Ng-Perron tests [103] are applied with intercept and trend. These tests are important in terms of choosing a suitable model, avoiding spurious regressions, and determining the presence of any structural break in the time series [62].

However, the F-bounds test approach is employed to verify the existence of an equilibrium relationship. The autoregressive distributive lag (ARDL) framework has commonly been used due to its ability to fill the gap created by the drawbacks of other co-integration techniques [104,105]. Furthermore, using this technique has a number of advantages, as discussed in past studies [30,54,106–108]. This technique is appropriate for small sample sizes ($30 \le n \le 80$) and far superior to other co-integration techniques [109,110]. The dynamic relationship among the variables of this study is formulated as in Equation (5):

$$\Delta \begin{bmatrix} LY \\ LK \\ LM \\ LE \\ LF \\ LI \\ LN \end{bmatrix}_t = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} & \alpha_{17} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} & \alpha_{27} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} & \alpha_{36} & \alpha_{37} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} & \alpha_{46} & \alpha_{47} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & \alpha_{56} & \alpha_{57} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} & \alpha_{67} \\ \alpha_{71} & \alpha_{72} & \alpha_{73} & \alpha_{74} & \alpha_{75} & \alpha_{76} & \alpha_{77} \end{bmatrix} \begin{bmatrix} LY \\ LK \\ LM \\ LE \\ LF \\ LI \\ LN \end{bmatrix}_{t-1} + \sum_{m=1}^{k} \Delta \begin{bmatrix} \theta_{11} & \theta_{12} & \theta_{13} & \theta_{14} & \theta_{15} & \theta_{16} & \theta_{17} \\ \theta_{21} & \theta_{22} & \theta_{23} & \theta_{24} & \theta_{25} & \theta_{26} & \theta_{27} \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} & \theta_{35} & \theta_{36} & \theta_{37} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & \theta_{45} & \theta_{46} & \theta_{47} \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} & \theta_{56} & \theta_{57} \\ \theta_{61} & \theta_{62} & \theta_{63} & \theta_{64} & \theta_{65} & \theta_{66} & \theta_{67} \\ \theta_{71} & \theta_{72} & \theta_{73} & \theta_{74} & \theta_{75} & \theta_{76} & \theta_{77} \end{bmatrix}_m \begin{bmatrix} LY \\ LK \\ LM \\ LE \\ LF \\ LI \\ LN \end{bmatrix}_{t-m} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix}_t \tag{5}$$

4.2. Estimation procedure

Utilizing econometric procedures, a stationary test is important to ascertain that the data have no trend over time so that the hypothesis tests are valid. This is because the stationarity or non-

where Δ is the first difference operator, $\delta_i s$ represents the intercepts, and $\alpha_{ij}s$ and $\theta_{ij}s$ denote the long- and short-run coefficients of the variables, respectively. $\varepsilon_{it}s$ indicates the error terms, k is the lag length, and m is the optimal number of lags. The Akaike

Table 3
Data sources and variables definition.

Variables	Proxy/Measurement	Data sources	Past studies used
Y	Real gross domestic product	WDI	[70,86]
K	Gross fixed capital formation (GFCF)	WDI	[86,87]
M	Total employment	WDI	[36,88]
E	Electricity consumption (ktoe)	WDI	[86,89]
F	Domestic credit to private sector	WDI	[53,62]
I	Composite measure	ICRG	[17,59]
N	Finance x Institution	WDI, ICRG	[34,90]

Note: ICRG is International Country Risk Guidelines.

information criterion (AIC), Shwartz Bayesian criterion (SBC), and Hannan-Quinn (HQ) are commonly used [30,96,97,111].

The decision to reject or fail to reject H_0 (no co-integration) is actually based on comparing the calculated F-test results with the critical values tabulated in statistical tables [109]. If F-statistics > I(1) critical value, the H_0 of no co-integration is rejected (a long-run relationship exists). If F-statistics < I(0) critical value, the H_0 of no co-integration cannot be rejected (no long-run relationship exists). If I(0) ≤ F-statistics ≤ I(1) critical value, the decision is inconclusive. In this case, the stationarity of the residuals will be verified. If the residuals are stationary, the variables are co-integrated and vice versa [54]. Once the dynamic relationship among the variables has been confirmed, the long-run elasticity of economic growth toward the changes in capital, employment, electricity consumption, financial development, governance institution quality, and finance-institution interaction can be estimated. The vector error correction model (VECM) and unrestricted vector autoregression (VAR) model framework is used to investigate the direction of causality among the above variables [91,92]. Therefore, the long- and short-run causality among variables is formulated as in Equation (6).

approach of estimating long-run equilibrium in systems that may involve variables integrated on different orders or co-integrated. The potential for simultaneity bias and small-sample bias among the regressors is dealt with by the inclusion of lagged and leading values of the change in the regressors [114].

5. Results and discussion

Table 4 provides the quality data testing and interrelationship matrix results. It displays that the variables of the current paper are normally distributed, as shown by skewness and Jarque-Bera normality tests. The results indicate that real GDP has a significant and positive correlation with its determinants, namely, *K, M, E,* and *F.* Real GDP has a high correlation with employment, electricity consumption, and capital and a medium correlation with financial development. This means that a positive association exists between GDP and its determinants, supporting the argument in the existing literature that *K, M, E,* and *F* are important factors in shaping future sustainable growth of the Malaysian economy as a whole [14,115]. A positive correlation is found between governance institution quality (*I*) and financial development (*F*) and between interaction of

$$\Delta\begin{bmatrix} LY \\ LK \\ LM \\ LE \\ LF \\ LI \\ LN \end{bmatrix}_t = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix} + \sum_{j=1}^{m} \Delta \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} & \alpha_{17} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} & \alpha_{27} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} & \alpha_{36} & \alpha_{37} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} & \alpha_{46} & \alpha_{47} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & \alpha_{56} & \alpha_{57} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} & \alpha_{67} \\ \alpha_{71} & \alpha_{72} & \alpha_{73} & \alpha_{74} & \alpha_{75} & \alpha_{76} & \alpha_{77} \end{bmatrix}_j \begin{bmatrix} LY \\ LK \\ LM \\ LE \\ LF \\ LI \\ LN \end{bmatrix}_{t-j} + \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \\ \gamma_6 \\ \gamma_7 \end{bmatrix} \begin{bmatrix} ECT_1 \\ ECT_2 \\ ECT_3 \\ ECT_4 \\ ECT_5 \\ ECT_6 \\ ECT_7 \end{bmatrix}_{t-1} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix}_t \quad (6)$$

A short-run causality relationship (unidirectional, bidirectional, and neutral) can be detected based on the significance of the coefficients, α_{ij}s for each explanatory variable by joint Wald F or χ^2 test. Meanwhile, a long-run causality relationship can be detected based on coefficients, γ_is of ECT_{t-1} by using the *t*-test, where $ECT_{t-1}s$ represents lagged error correction terms derived from the long-run relationship. The white noise error terms, ε_i (i = 1, ….6), are normally distributed with zero mean and constant variance, $\varepsilon_t \sim N(0,\sigma^2)$, homoscedastic, with no autocorrelation and multicollinearity problems. Therefore, the ARCH, Breusch-Godfrey, Breusch-Pagan-Godfrey, and RAMSEY tests are utilized to ascertain that the estimated model is free from the above problems [53,107]. In addition, cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares (CUSUMQ) tests [112] are used to ascertain the stability of the model. The model is stable if the plot of CUSUM and CUSUMQ tests stays within the critical boundaries of the 5% significance level. Also, this paper uses the DOLS test to check model robustness. This is more robust method, particularly for small samples sizes [113]. It shows a parametric

technological innovation and governance institution quality (*N*) and financial development. Higher levels of governance institution quality and interaction of technological innovation and governance institution quality boost financial development, which in turn stimulates economic growth [80].

Furthermore, Table 5 reveals that all the variables used in this paper have a mixed order of integration, which is stationary at levels, I(0), and at first differences, I(1), at the 1% and 5% significance levels. These results indicate that the H_0 of the unit root test is rejected at the 1% and 5% significance levels.

Based on the results (Table 5) and small sample size (31 years), the ARDL bounds test is the most suitable method to further test the dynamic equilibrium relationship among the above variables. Furthermore, the optimal lag order (*k*) of the variables is 2, using AIC. This is because it performs well in a small sample size and at the same time minimizes the degree of loss of freedom [92,96,111,116,117].

According to the results (Table 6), the H_0 of no co-integration among the variables in the GDP and capital models is rejected at

Table 4
Descriptive statistics, normality test and correlation matrix (1985–2015).

	LY	*LK*	*LM*	*LE*	*LF*	*LI*	*LN*
Descriptive statistics							
Mean	19.99938	18.69826	9.095175	8.355186	9.303804	0.628808	5.852817
Median	20.07606	18.71530	9.134452	8.5688266	9.295694	0.611111	5.677578
Maximum	20.78177	19.44164	9.553850	9.356920	9.647899	0.805556	7.318061
Minimum	19.04131	17.61294	8.640012	6.930495	8.845240	0.555556	4.914022
Std. Dev.	0.526259	0.487267	0.265973	0.767766	0.184861	0.070735	0.690199
Skewness	−0.361913	−0.732117	−0.067771	−0.540542	−0.423149	1.087378	0.939865
Kurtosis	2.015955	2.892005	1.993757	1.989505	3.304564	3.073998	2.809861
Jarque-Bera	1.927512	2.784371	1.331576	2.828547	1.044933	6.116090	4.610651
Probability	0.381457	0.248532	0.513869	0.243102	0.593056	0.046979	0.099726
Correlation matrix							
LY	1						
LK	0.891728	1					
LM	0.991319	0.865804	1				
LE	0.989764	0.866606	0.977883	1			
LF	0.468531	0.537121	0.445530	0.509586	1		
LI	−0.339634	−0.239865	−0.339518	−0.312254	0.198236	1	
LN	−0.244036	−0.131767	−0.248746	−0.211478	0.360240	0.985472	1

Table 5
Stationary tests results (Trend with Intercept).

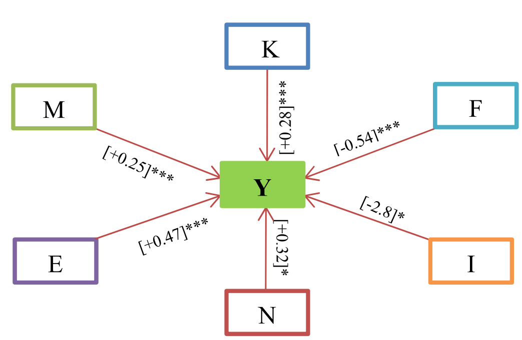
Variables	ADF		P-P		KPSS		NP		Inference
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
LY	−1.797	−5.3***	−1.797	−5.34***	0.72**	0.071	−4.81	−13.50	I(1)
LK	−1.178	−4.07**	−1.241	−4.02**	0.57**	0.087	0.342	−12.96	I(1)
LM	−0.154	−6.0***	−0.09	−6.06***	0.73***	0.115	−7.18*	−14.12	I(1)
LE	−1.396	−2.675	−1.747	−8.44***	0.70**	0.090	−34***	−18**	I(1)
LF	−7.18***	−5.47***	−1.97	−5.47***	0.218	0.08	−4.55	−14.2	I(1)
LI	−4.84***	−4.10**	−2.95*	−3.62**	0.207	0.071	−2.93	−12.8	I(1)
LN	−4.77***	−3.31**	−2.73*	−3.36**	0.130	0.068	−11.3**	−12.09	I(0)

Notes: ***, **, * indicate 1%, 5% and 10%, level of significant respectively.

Table 6
Co-integration test results (F-statistical test).

Estimated models	Optimal lag length	F-statistics	Significant level	Critical values bounds		Decision
				Lower	Upper	
LY| *LK, LM, LE, LF, LI, LN*	1,2,2,2,1,2,0	10.68***	1% level	4.270	6.210	Co-integration
LK| *LY, LM, LE, LF, LI, LN*	1,1,0,1,1,1,1	11.16***	5% level	2.970	4.499	Co-integration
LM| *LY, LK, LE, LF, LI, LN*	1,1,0,1,0,1,0	0.649	10% level	2.457	3.797	No Co-integration
LE| *LY, LK, LM, LF, LI, LN*	1,0,1,0,1,0,0	3.670				No Co-integration
LF| *LY, LK, LM, LE, LI, LN*	1,1,0,0,1,1,1	2.152				No Co-integration
LI| *LY, LK, LM, LE, LF, LN*	1,1,1,0,0,1,1	0.871				No Co-integration
LN| *LY, LK, LM, LE, LF, LI*	1,1,0,0,0,1,1	0.925				No Co-integration

Note: (1) ***,** and * as defined in Table 5. (2) Critical value obtained from Narayanan (2005) for unrestricted intercept and no trend (case III).



Notes: (1)***,**, and * as defined in Table 5. (2) Diagnostic tests: Jarque-bera = 0.33(0.85); Breusch-Godfrey Serial Correlation = 1.64(0.20); Breusch-Pagan-Godfrey = 1.95(0.16); ARCH = 1.30(0.26); Ramsey RESET = 0.83(0.36); (3) ect_{t-1} = -1.2(0.00)***.

Fig. 5. Long-run elasticities/coefficients of economic growth and its determinant.

the 1% significance level. This confirms the existence of long-run relationships among the variables. On the other hand, the other models show that the calculated F-statistic value is less than the upper bound [I(1)], which means that there is no co-integration among the variables; thus, the H_0 for these models is not rejected.

Furthermore, to check the degree of sensitivity (responsiveness) of GDP due to the changes in its determinants, an elasticity measure is used. Long-run relationship and elasticities between economic growth and its determinants are shown in Fig. 5. The findings display significant long-run responsiveness of these variables (*K, M, E,* and *F*) at the 1% significance level.

The long-run GDP-capital elasticity is inelastic; a 1% rise in capital promotes economic growth to a fair degree of 0.28%, ceteris paribus. This finding is consistent with several empirical studies in this field [64,118,119] for the case of Algeria, Turkey, and China, respectively. This finding implies that capital in terms of physical capital and infrastructure (typically roads, railways, buildings, machinery, dwellings, vehicles, technology, and others) has a significant positive impact on economic growth of the Malaysian economy. This is proven by an average annual growth rate of Malaysia's capital of 8.8% per year for the 1985–2015 period (see Fig. 3). Well-structured infrastructure, like transport, digital, and energy infrastructure at one point, is well provided, which expands economic sectors and attracts investment from other countries [20].

The long-run GDP-employment elasticity indicates inelastic responsiveness, where a 1% rise in employment promotes economic growth with a fair degree of 0.25%, ceteris paribus. This is in line with Dogan [119] for the case of Turkey. This finding shows that employment via human capital plays an important role in terms of knowledge transmission and technology know-how to fuel economic growth [2]. Human capital and learning capability are vital factors of economic development, which are responsible for a country's absorptive capacities [120,121], domestic technological innovation [122], and regional development [67]. Also, the long-run GDP-electricity consumption elasticity shows an inelastic responsiveness; a 1% rise in electricity consumption promotes economic growth of a moderate degree of 0.47%, ceteris paribus. In this view, electricity consumption can be considered a driving force of production that plays an important role to stimulate economic growth. This finding is consistent with Dogan [119] and Hamdi et al. [63] for the case of Turkey and Bahrain, respectively.

On the other hand, the long-run GDP-financial development elasticity and the long-run GDP-quality of governance institution elasticity appear negative and significant individually. However, the long-run GDP-N (Finance-Institution) elasticity appears positive and significant at 0.32 at the 10% significance level when interaction of these two variables is considered. These results prove that interaction of technological innovation via financial development and the governance institution quality support one another. This means that financial development progress must be accompanied by governance institution quality. Castellaci and Natera [42] point out that quality of institutions and governance systems is one of the important factors influencing a country's absorptive capacity. Furthermore, it influences a country's level of economic development. In view of this finding, technological innovation progress can only be achieved with the help of governance institution quality. According to Law and Azman-Saini [82], institutional reforms generally improve financial development; however, the magnitude might vary with the level of economic development.

The value of ECMs verifies the negative sign and is statistically significant at 1%. This indicates that any deviation from the short-run disequilibrium among the variables is corrected in each period to return to the long-run equilibrium level. Thus, the information given by ECM is important to understand how fast it can be corrected to return to the long-run equilibrium. It reveals that the rate of adjustment in returning to equilibrium for the GDP model [*LY*] is gradual. Furthermore, the results of the diagnostic tests pass serial correlation, functional form, normality, heteroscedasticity, and ARCH tests. Also, CUSUM and CUSUMSQ tests are used to check the long-run stability of residuals for the GDP model. Fig. 6 shows the stability of the long-run parameters as the plot of CUSUM and CUSUMSQ statistics stays within the critical boundaries of the 5% significance level [30,119,123]. This confirms that the estimated regression of co-integration is stable. Therefore, the above model can be employed for policy-making purposes as it follows a stable trend during the estimation period (1985–2015).

To confirm the long-run estimation results, the DOLS and ARDL estimators are compared. The DOLS estimators indicate efficient co-integrating vectors and the regression results are most likely consistent with ARDL estimates for the GDP model (see Table 7). Similarly, capital, employment, electricity consumption, and finance-institution variables have positive significant signs, similar to ARDL estimates. In the meantime, capital, employment, and electricity consumption are significant and positive in the aforementioned model. Based on the result, electricity consumption is a crucial factor for the sustainable growth of Malaysia. A 1% increase in electricity consumption will increase economic growth by 0.45% and 0.48% for the ARDL and DOLS models, respectively.

To ascertain the causal relationship between variables, this study applies the VECM Granger causality framework. This is because the direction of causality between each individual variable is important to forming policies regarding electricity consumption, technological innovation, governance institution quality, and sustainable growth. Fig. 7 illustrates the causality direction between each and the individual directions of presented variables for the GDP model in the long run as well as the short run. The results indicate short-run unidirectional causality of capital, employment, and governance institution quality on economic growth at the 1% significance level and interaction of financial development and governance institution toward economic growth at the 5% significance level. The unidirectional causality of capital pointing toward economic growth is consistent with Amri [118] for the case of Algeria. Meanwhile, the unidirectional causality of employment pointing toward economic growth is in line with Awad and Yossof [124] and Shahbaz et al. [125] for the case of Sudan and Portugal, respectively. Also, the result shows that bidirectional causality exists between electricity consumption and economic growth, which reflects the existing feedback hypothesis of an electricity-growth nexus in the current paper. This result is consistent with Polemis and Dagoumas [126] for the case of Greece, Apergis and Payne [127] for the case of high- and upper-middle income country panels, and Tang [128] and Yoo [129] for the case of Malaysia and Singapore. Also, the results indicate bidirectional causality between financial development and economic growth. The same finding has been disclosed by Bekhet and Al-Smadi [92] for the case of Jordan. Furthermore, the results indicate long-run unidirectional causality running from governance institution [*I*] to financial development. Also, long-run unidirectional causality runs from interaction of finance-institution [*N*] to financial development. The same finding has been disclosed by Law and Azman-Saini [82].

6. Conclusions and policy implications

This study explores the dynamic relationship between real GDP, capital, employment, electricity consumption, technological innovation (financial development), governance institution quality, and interaction of financial development and governance institution quality in Malaysia for the 1985–2015 period. In contrast to previous studies, this study has highlighted the importance of quality

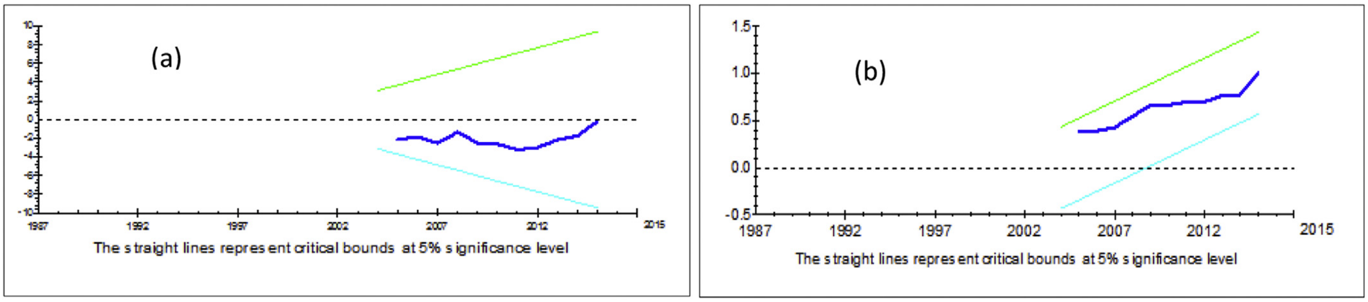


Fig. 6. (a) and (b): CUSUM and CUSUMSQ plots of ECT for the (1985–2015) period.

Table 7
Results of the DOLS and ARDL for GDP model.

Variables	Coefficients	t-statistics	Probability	Coefficients	t-statistics	Probability
	DOLS			ARDL		
lnK	0.240***	6.613	0.007	0.280***	13.66	0.000
lnM	0.326*	2.483	0.089	0.245***	4.157	0.001
lnE	0.449***	14.13	0.000	0.475***	28.08	0.000
lnF	−1.36***	−6.10	0.008	−0.54***	−5.31	0.000
lnI	−15.6**	−4.57	0.019	−2.85*	−1.79	0.970
lnN	1.700**	4.658	0.019	0.32*	1.897	0.820
C	21.4***	11.02	0.002	13.54***	13.62	0.000

Notes: (1)***,**, and * as defined in Table 5.

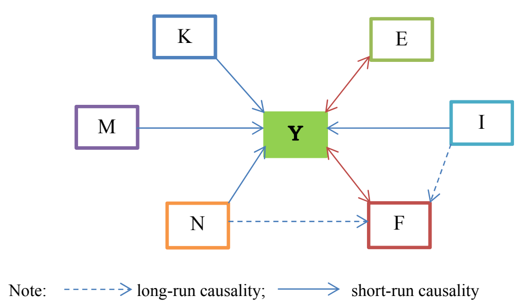


Fig. 7. Direction of causality relationship among variables for GDP model.

of governance institutions in promoting technological innovation and the interaction impact of finance-institution to stimulate economic growth. The F-bounds testing approach and VECM Granger causality test are utilized to check for the existence of co-integration and the direction of causality among variables.

Primarily, this study has provided a new dimension regarding the role played by governance institutions in the efficiency of financial development as a proxy for technological innovation. The study reveals that governance institution quality influences financial development. An important finding from this study is the negative and significant impact of technological innovation (proxied by financial development) and governance institution quality on economic growth in the long run. However, the interaction of these two variables (technological innovation and governance institution quality) has a positive and significant impact on economic growth at the 10% significance level under the ARDL model and 5% significance level under the DOLS model. The empirical results prove that governance institution quality is vital to influence the financial sector and, in turn, increase long-term economic growth [59,130]. This can be achieved by improving the quality of governance institutions, for example, reducing corruption and improving government efficiency and transparency [80]. Thus, high-quality governance institutions will enhance the financial sector to become more resilient, efficient, and competitive in the attempt to achieve sustainable growth and development. The efficiency of the financial sector may facilitate allocation of the funds needed without any circumstances of leakage. This demonstrates that the quality of institutions plays an important role in upgrading technological innovation. In terms of the causality relationship, the study reports significant unidirectional causality from governance institution quality and finance-institution to financial development in the long run and bidirectional causality between financial development and economic growth in the short run. These results may help policy makers in terms of finding suitable policies to enhance the technological innovation progress for sustainable growth to benefit society as a whole. Nevertheless, this finding can enhance existing policies in several ways:

(i) Developing countries can be considered latecomers that may have greater potential for growth than developed countries. They have an advantage in terms of their lower effective cost in creating new and better products. Thus, there is room for greater improvement in the catching-up process of technological progress [47]. Technological innovation progress can be divided into the first stage of upgrading technological innovation development (imitation and adoption) and the second stage of technological innovation (innovation domestically). However, in developing countries like Malaysia, technological innovation progress is mainly through imitation, such as through foreign direct investment, trade, or transfer of foreign technology. At this stage, absorptive capacities are very important and need time and resources. Absorptive capacities refer to a society's ability to absorb knowledge and skills and learn quickly. Malaysia's labor force was approximately 14 million in 2015, with skilled workers accounting for only 28% of total employment. Therefore, Malaysia's aims to achieve 35% skilled workers by 2020 [2,20]. The availability of a skilled and educated workforce is extremely important in adopting, imitating, and further understanding new technologies. This is important because it may facilitate the assimilation of foreign technology by the nation's society as a whole. Assimilation is a process of taking in and fully understanding any given information, knowledge, or ideas and maintaining curiosity with regard to knowledge, an attitude that at some point becomes a society's culture [68]. In addition, new technologies necessitate proper and adequate training for existing workers. It is difficult for workers to adapt, adopt, and learn new technologies without proper knowledge. Although Malaysia is full of talent, a brain drain of well-educated and high achievers in Malaysian has provided a challenge in becoming an innovation society. In this scenario, Malaysia has taken an appropriate approach by setting up TalentCorp in January 2011 and initiating the Returning Expert Programme (REP) as a solution [20]. However, this situation has its own advantages, such that, if this group of people is coming back, they may bring in new technology, new ideas, new skills, and new business approaches and cultures which benefit the country (brain circulation); or else, it become a disadvantage to Malaysia.

(ii) Furthermore, the country's ability to provide good and well-structured infrastructure via physical capital [47] is essential. In 2016, Malaysia ranked second in Asia and fifth globally in terms of attractiveness for infrastructure investment based on the Global Infrastructure Investment Index [38]. Also, Malaysia ranks 32nd (out of 160 countries) in the logistics performance index, which measures performance on trade logistics in 2016 [131]. One of the indicators is competence and quality of logistic services (e.g., ports, railroads, roads, information technology). These make Malaysia's market attractive for private and inward investment. Furthermore, they create a business-friendly environment to further drive economic growth and productivity [132]. This is consistent with the National Transformation Programme's highlighting the importance of infrastructure in achieving Malaysia's transformation into a developed nation by 2020 [20]. Therefore, Malaysia is expected to ensure the improvement and sustainability of existing and new infrastructure on its way to achieve the 2020 goals.

(iii) New technologies require large amounts of investment and must be supported by quality governance institutions. Allocation of significant amounts of the government budget and funding (public and private) to factors that enhance technological innovation is crucial (e.g., science education, gross education enrolment rate, internet connectivity, research and development, human capital). A lack of or inadequate funding may pull down any effort the government makes which is not synchronized with the vision and mission of the country to become developed country. The involvement of all parties, such as the public and private sector, is very much needed. Low involvement of the private sector in R&D activities and lack of good researchers in science and technology may drag down technological progress. To attract young scientists and innovators, giving awards or incentives for any breakthrough and providing a marketing channel to materialize it are seen as motivating. All in all, financial institutions and quality of government institutions play an important role from the beginning stage to the end (adoption, imitation, and innovation).

(iv) On the other hand, it is important to create a balance and coherence in the policy mix to ensure the rationality, consistency, and soundness of all institutions in terms of implementation [78]. The policy process can be empowered by introducing a silo with policy integration among institutions and monitoring short-term, medium-term, and long-term future plans for any circumstances of leakage or waste. Furthermore, government may drop a portion of corporate taxes for developing an innovative product and production process that are environmentally friendly and economically viable.

(v) Technological “leap-frogging” cannot be achieved without a steady supply of electric power to all communities, urban and rural. Providing that, nobody will be left out of this technological innovation progress. Now, with the Internet of Things (IoT), computerization, digital economy (eD), and Industrial Revolution 4.0 (IR4), a steady supply of electrical technology is a catalyst. Malaysia has targeted its digital economy to contribute about 20% to its GDP by 2020 [133]. Currently, Malaysia is concentrating on transforming its economy based on innovation-led growth. Thus, the government must provide environmentally friendly electricity consumption to achieve both sustainable energy and sustainable growth.

Technological innovation is still in the beginning phase in Malaysia, so it has had little effect on Malaysia's economic growth. Foreign technology transfer via trade, foreign direct investment, and financial liberalization from the 1980s onward has been of significant help to Malaysia. However, domestic technological innovation is extremely important, as it is a way to further upgrade the capability to catapult Malaysia into being a developed country. Furthermore, technological innovation progress must be accompanied by quality in governance institutions. The influence of systematic policy rationales will place the focus of technological innovation progress on the right track. Technological innovation is a risky business with considerable cost and an uncertain outcome, but without rigorous effort, the desired outcome cannot be achieved. Technological innovation needs a long time period and continuous effort to realistically become an important source of growth. Malaysia is in dire need of becoming a domestically innovative country to achieve sustainable growth and development. In future studies, other variables can be included, such as materialization and marketing of technological innovation.

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